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Water self-diffusion behavior in yeast cells studied by pulsed field gradient NMR

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Abstract

The water self-diffusion behavior in yeast cell water suspension was investigated by pulsed field gradient NMR techniques. Three types of water were detected, which differ according to the self-diffusion coefficients: bulk water, extracellular and intracellular water. Intracellular and extracellular water self-diffusion was restricted; the sizes of restriction regions were approximately 3 and 15–20 μm, respectively. The smallest restriction size was determined as inner cell size. This size and also cell permeability varied with the growth phase of yeast cell. Cell size increased, but permeability decreased with increasing growth time. The values of cell permeabilities P_1^d obtained from time dependence of water self-diffusion coefficient were in good agreement with the permeabilities obtained from the exchange rate constants P_1^{eff}. The values of P_1^{eff} were 7×10^{-6}, 1.2×10^{-6} and 1.6×10^{-6} m/s, and P_1^d were 6.3×10^{-6}, 8.4×10^{-7}, 1.5×10^{-6} m/s for yeast cells incubated for 9 h (exponential growth phase), 24 h (end of exponential growth phase), and 48 h (stationary growth phase), respectively.

Keywords: Pulsed field gradient NMR; Water self-diffusion coefficient; Yeast; Growth phases

1. Introduction

Water transport in biological systems is important for cellular physiological reactions, osmotic pressure of tissue and drying process of biological materials. Transport of water in cellular system occurs either by osmotic gradient or by self-diffusional processes [1]. Osmotic water flow can be measured by monitoring changes in light scattering [2] of cell in concentration-dependent manner by fluorescence microscopy or by cell turgor pressure [3]. For diffusional water permeability, pulsed field gradient NMR (PFG-NMR) spectroscopy has become the method of choice due to its remarkable sensitivity to molecular displacements in the range of 10 nm–100 μm and to its non-invasive character [4,5].

Recently, Benga et al. [6,7] measured the diffusional water permeability of red blood cells from

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